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ENGINEERING AND FABRICATION OF THE "OFF THE CUFF" PAVILION, FUORISALONE 2017, MILAN

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Summary. The paper presents the engineering and fabrication of the "Off The Cuff" pavilion designed by Diller Scofidio + Renfro for the exhibition "A Matter of Perception: LINKING MINDS" organised by DAMNº and Mosca Partners at Palazzo Litta for the FuoriSalone2017.

The roof canopy is composed of 300 pairs of jeans. DS+R deploys the jeans as ready-mades, intentionally misusing and translating them from the context of the human body into an architectural module.

The design exploits the implicit structural logic of the jeans connecting them waist-to-waist and cuff-to-cuff to create a tensile, catenary diagrid that spans the open space of the courtyard. The net gives the impression of a body imprinted in space, but one also defamiliarised by repetition.

As an architectural figure, the net springs across the courtyard, describing a collective ethos; as a series of modular parts, the jeans point to the individual human dimension. A contemporary folly in the bracketed context of monumental classicism, the canopy stitches together two vital scales of urban life.

The authors, with Maco Technology srl as main contractor and the University of Nottingham as structural consultant, worked as project managers for the pavilion supporting DS+R from the progressive development of the initial idea to the fabrication and installation of the pavilion. The activity here presented included the refining the preliminary engineering design done by Thornton Tomasetti and the selection of the suppliers.

1 INTRODUCTION

Every year the "Salone del Mobile" represents one of the main international events for Milan with more than 343.600 attendees in 6 days from 165 countries. During the same days the city becomes the international capital of design with hundreds of events and exhibitions organized around the City.

The pavilion “Off the Cuff” is the main installation of the third edition of the ‘A Matter of Perception’ exhibition which explored the theme of LINKING MINDS. The exhibition, organized by Mosca Partners and DAMN°, was hosted by Palazzo Litta which is itself a fascinating example of Lombard Baroque architecture in the city and an expression of the connection between Milanese culture and the French and English Enlightenment (fig. 1).

The pavilion was designed by Diller Scofidio + Renfro, an interdisciplinary design studio based in New York City that integrates architecture, the visual arts, and the performing arts. According to Liz Diller, the initial concept was based on the idea of “using ready-made modules – actually misusing them – for architectural purposes. In the back of our minds – and this might sound very peculiar – we have always wanted to use actual trousers as a module” [1].

Maco Technology and the University of Nottingham were contacted in January 2017 in order to provide the support for the final engineering, manufacturing and installation of the pavilion by the 3rd of April 2017.

Figure 1: View of Palazzo Litta, location of the exhibition ‘A Matter of Perception: LINKING MINDS 2017”. The palace is placed in in the 5VIE design district.

3 THE TECHNICAL SOLUTIONS ADOPTED

The project has been challenging under several aspects such as the extremely tight time schedule, the constraints imposed by the Monuments and Fine Arts Department, the building materials used and the complex 3D modelling of the structure.

The reduced time available for the project, 12 weeks in total, imposed the development of a final version of the initial idea in less than 6 weeks in order to start the manufacturing of the

components (4 weeks), the preassembly of the units (1 week) and the final installation (1 week).

The canopy (fig. 2) is a jean fabric grid stretched between cable-stay posts . Structural stability is ensured through a balance of form-finding and the base structure which resolves the system without the need for heavy ballast under the ties. Material testing was performed to verify the structural integrity of the denim and connections with transmitted forces of up to 2kN. Thin Kevlar rope was introduced as an erection aid and remains to provide supplementary support to the system. A PVC foil sits above the denim and kevlar mesh.

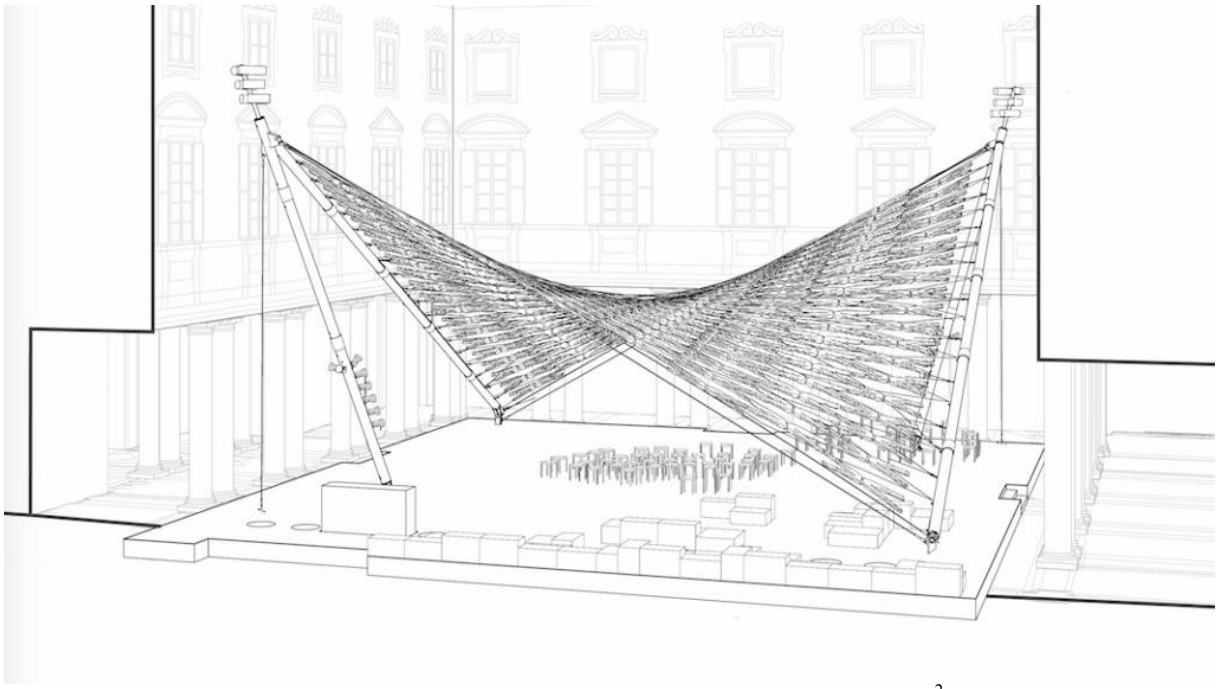

Figure 2: 3D view of the pavilion by Diller Scofidio + Renfro[2]

The main challenge was to optimize the shape of the pairs of trousers which had to fit the mesh selected by the architect and the size of the inflatable mannequins available on the market (Fig. 3). Thanks to a form finding algorithm it has been possible to adjust the geometry of the surface in order to have only one module and, consequently, only one size of trousers to be produced. The required strength of the trousers has been achieved by increasing the number and size of the belt loops and by inserting a metal ring in correspondence of the cuffs.

The elongation of the denim under load and in presence of different levels of humidity has been addressed through adjustable connections (cable ties) in correspondence of the cuffs and the waist of each unit and adding a set of adjustable Kevlar ropes between the steel frame and the mesh in order to introduce the required level of pretension into the tensile structure. The length of the Kevlar rope was controlled by means of a GI-GI plate, a multiuse belay plate commonly used for climbing.

The mesh was supported by a rigid steel structure designed to avoid the transfer of additional loads to the existing building apart from the gravity loads. The final structural

solutions did not require permanent foundations, anchoring points or heavy ballasts. The vertical loads have been distributed on the ground through thick timber boards.

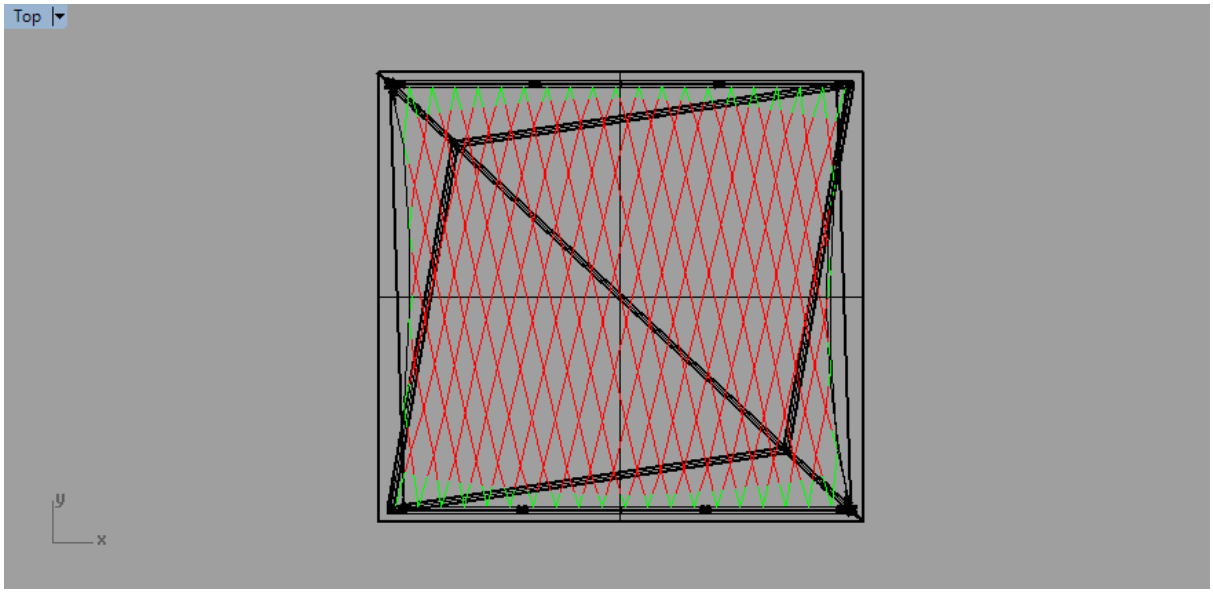

Figure 3: Top view of the mesh with the units with a fixed length (in red) and the adjustable Kevlar ropes (in green)

In order to facilitate the installation of the steel structure, the two main posts have been designed with pinned joints able to allow the rotation from the initial horizontal plane, used for the connection of the components at ground level, to the vertical plane required by the final geometry of the pavilion. Each post was stabilized by two cables (Full Locked Coil by Redaelli Tecna) connected to the basement.

4 DESIGNED AND MANUFACTURING OF THE TROUSERS

The final design implemented several solutions designed to optimize the manufacturing and installation of the pavilion. One key aspects was the manufacturing of the 360 pairs of trousers which had to be manufactured for the final mock-up and for the pavilion. Thanks to the optimization of the diamond mesh it has been possible to produces only one single model of trousers able to fit into all the units of the mesh.

The trousers (fig. 4) has been sponsored and manufactured by Trussardi Spa according to the specification developed considering the sized of the mesh, the dimension and shape of the connection, the required strength of the fabric and the aesthetic requirements. The main features included a set of eight reinforced belt loops, a total length equal to 96.5cm and a bespoke cuff able to host the metal ring used to distribute the tensile load into the full section of the trousers.

Once ready, the trousers were filled with inflatable mannequins, used to improve the shape and the structural stiffness, and pre-assembled in units of two connecting the belt loops with black cable ties and inserting the metal rings in correspondence of the cuffs. The cable ties provided the required strength and allowed the re-tensioning necessary to compensate the

progressive elongation of the jeans fabric and to adjust potential inaccuracies in the manufacturing and installation of the 304 pairs of jeans. Once completed, the units have been treated with a fire retardant liquid and transported onsite ready for the installation.

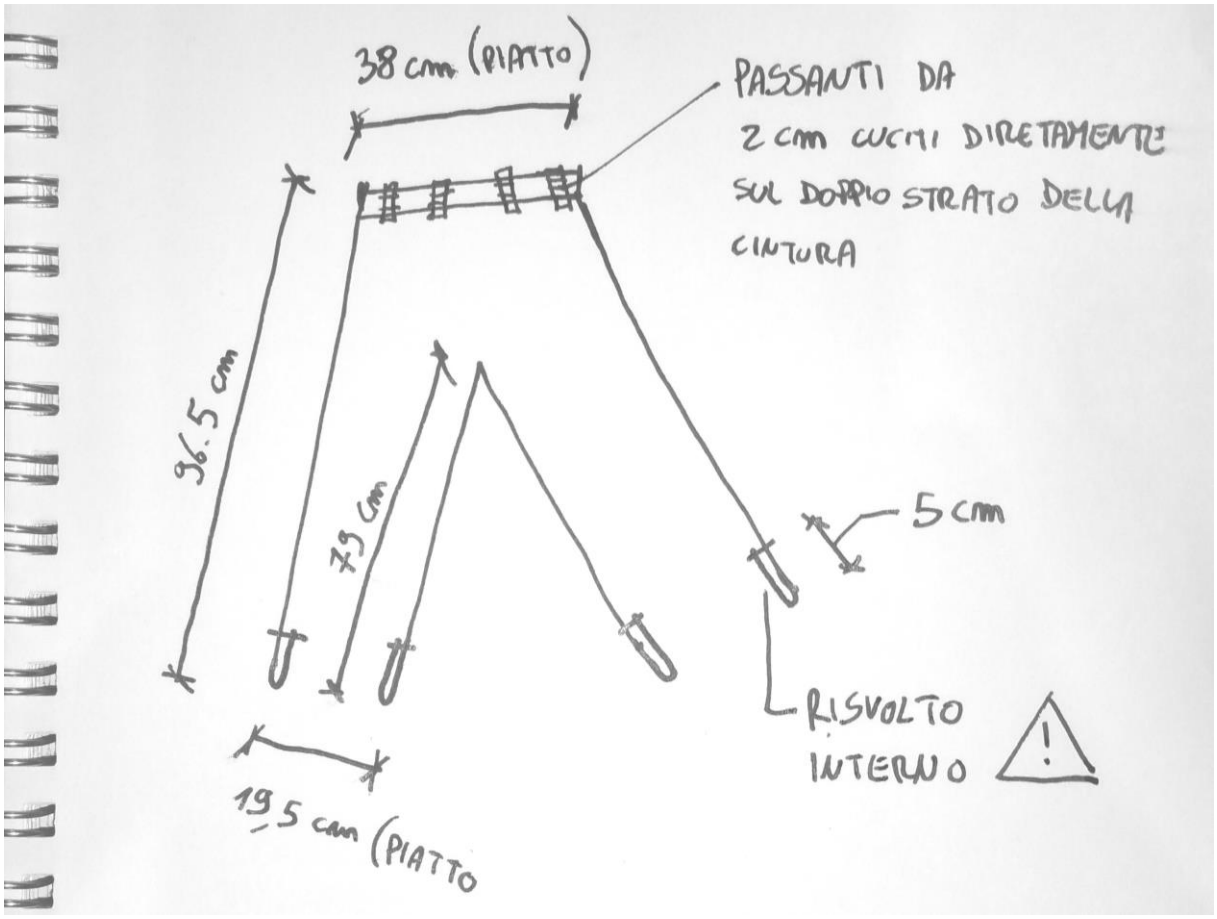

Figure 4: Copy of the sketch used for the production of the trousers.

5 INSTALLATION OF THE PAVILION

The installation of the pavilion was mainly driven by the limited access to the site which was located in one of the busiest areas of the historic centre of Milan. Due to the small size of the main gate and because of the reduced space available inside the courtyard, which was almost entirely occupied by the pavilion, the pavilion had to be subdivided in small components which could be easily moved and assembled by a team of 6 people with the support of the hydraulic crane installed on the truck used to deliver the components onsite.

In addition, the courtyard of the palace was available only for eight working days with a very tight programme that limited to a maximum of five days the time available for the erection of the structure of the pavilion.

The installation started with the assembly of the basement made by a rigid steel frame obtained by welding and bolting a set of hollow square sections 400x200x5mm (diagonals) and 260x260x4mm (perimeter). Timber beams were used to level the steel basement and to

spread the load in order to reduce the risk of damages to the ancient floor made of pebbles stones.

Figure 5: Installation of the steel structure. Detail of the Lifting of the steel posts[3].

Once completed the basement, the team of workers installed the lateral beams and posts which, thanks to the special pinned joints, were initially installed in the horizontal plane and then lifted by means of the hydraulic crane installed on the truck. A set of two cables were designed to stop the rotation of the steel structure once reached the correct position. The task was extremely challenging due to the limited space available and the risk of damaging the columns and the facades of the building.

The following step was the assembly of the mesh of safety Kevlar ropes designed to support the mesh of trousers during the installation and to provide an emergency support in case of failure of one, or more, of the units. Finally, the surface was completed with the installation of 304 pairs of trousers which were partially covered by a strip of PVC Crystal designed to protect the central part of the pavilion from the rain.

The installation included a bespoke lighting provided by Zumtobel and a timber floor used to cover the grid of beams used for the foundations.

Figure 6: Final adjustments of the level of pretension introduced in the mesh.

Figure 7: Detail of the structural connection between the throusers

Figure 8: View of the clear PCV foil applied on top of the pavilion

Figure 9: View of the mesh for underneath.

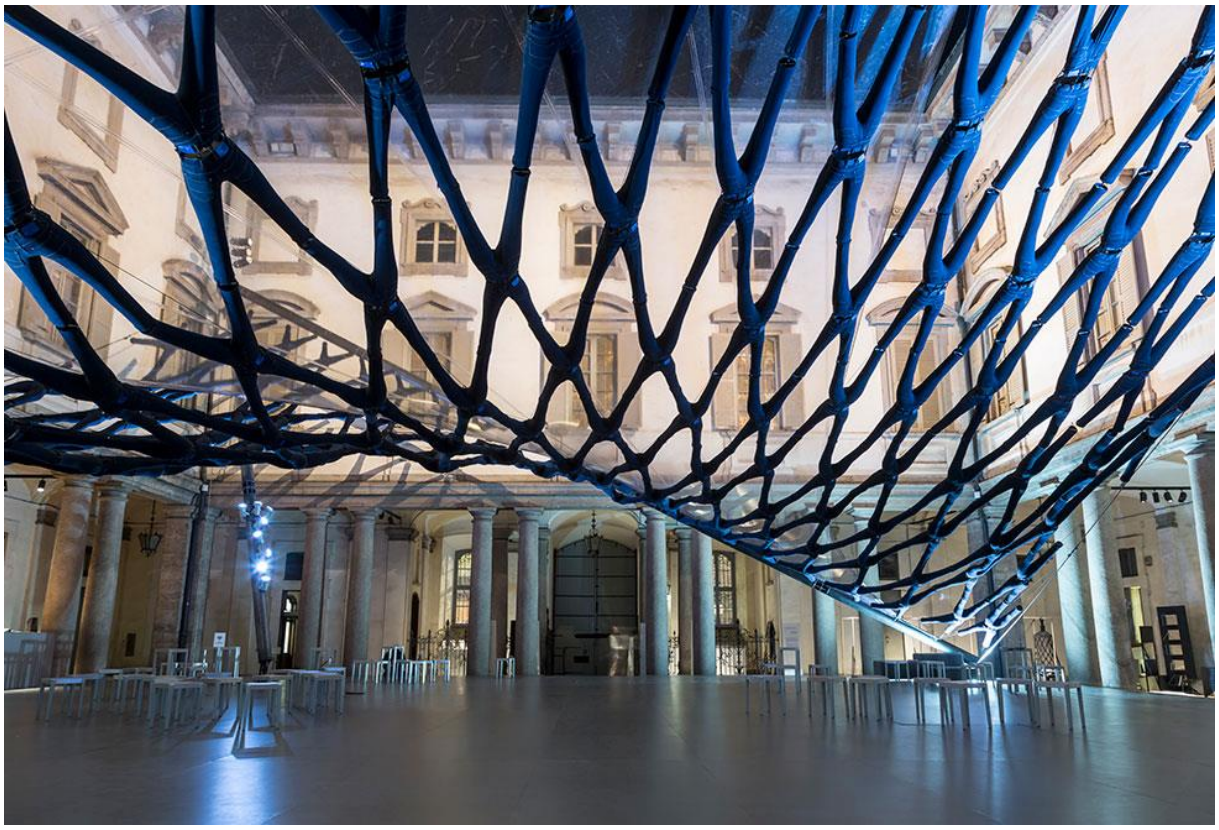

Figure 9: View of the pavilion at night (photo: Ruy Teixera)

CONCLUSIONS

The paper describes the design and manufacturing process of the "Off the Cuff" pavilion designed by Diller Scofidio + Renfro for the exhibition 'A Matter of Perception: LINKING MINDS 2017" presented during the Milan Design Week.

The description includes the technical solutions adopted during the structural design, the detailing, the manufacturing and installation.

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